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ANALYSIS OF MONSOON RAINFALL AND WIND SIMULATIONS ON FLOSOLVER USING THE VARSHA 1.2 GCM

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ABSTRACT: *The present work was intented to assess the ability of the GCM Varsha 1.2 of Flosolver , NAL to forecast the features of all India rainfall and 850 hpa wind during south west monsoon. The model was integrated for 30 days of each of the four monsoon months June, July, August and September with five different initial conditions for each. The study has been done for 21 years (1986-2006). Simulated wind and rainfall climatologies have been compared with observed ones. One month simulation for the monsoon months are studied to determine the skill of the model in simulating large scale features and organized rainfall. The correlations are calculated for simulated wind and rainfall with the observed values. The results show that the all India rainfall and 850 hpa wind compare reasonably well with that of the observation.*

1 INTRODUCTION

India receives most of its rainfall during the south-west monsoon, which spans from June to September. Since the monsoon is a system which has regional as well as global influences, accurate prediction of all facets of monsoon is a very hard problem. Among the various methodologies available, the use of general circulation models is the most promising approach for medium-range, extended range as well as seasonal forecasts. Though it is known that errors in a weather forecast grow rapidly, use of the ensemble technique enhances predictability, especially in the tropics. Also, recent theoretical and computational studies suggest that there are periods in a season which have a higher degree of predictability. It is based on such considerations that operational agencies like Japan Meteorological Agency and European Centre for Medium Range Weather Forecasts (ECMWF) have been making one month forecasts. A similar attempt has been made at the Flosolver Unit, National Aerospace Laboratories, Bangalore, with a spectral GCM named Varsha. Such simulations require a massive amount of computing power and have been made using the parallel computing systems at the Flosolver lab.

2 VARSHA GCM AND THE METHODOLOGY USED

Varsha is a spectral hydrostatic GCM which was developed at NAL, Bangalore as part of Govt. of India NMITLI project on ”Mesoscale modeling for monsoon related predictions”. Its roots lie in NCMRWF’s GCM T80 which was parallelized by NAL in the year 1993 [8] and was subsequently re-engineered using FORTRAN-90 [6]. New radiation and boundary layer schemes were added as part of NMITLI project [9].The model can be run at different physical grid resolutions and spectral truncations. For the present study, the model integration is performed with a spectral truncation T120 equivalent to a horizontal resolution of 80km. The model has 18 sigma levels in the vertical. Varsha 1.2 is the modified version of Varsha 1.0 GCM. Modifications in the numerics have resulted in a more smoother output.

The present analysis is done for the period 1986-2006 for the summer monsoon months June, J uly, August and September. Initial conditions for the model integration have been taken from the NCEP/NCAR reanalysis. [5] The model integration is done for one month. For each month, model integrations have been done using the initial conditions from the last two days of the previous month and the first three days of the current month, which constitute a five member ensemble.

In this paper, we present the analysis of the rainfall and 850hPa wind simulations of the model. A measure of the rainfall activity is the all India rainfall taken as the average rainfall over all the land grid points over India. This is an average over a sufficiently large area and also a quantity for which observations are available - daily rainfall on $1^o \times 1^o$ grid derived from raingauge data by Rajeevan

(2006) [7]. The wind data available from NCEP reanalysis at four times each day (00GMT, 06GMT, 12GMT, 18GMT) have been averaged over the region 12.5^o-17.5^{o}N, 70^o-95^{o}E [4]. The simulated wind is also available at 6hr intervals each day. Zonal component of these have also been averaged over the same box.

3 RESULTS

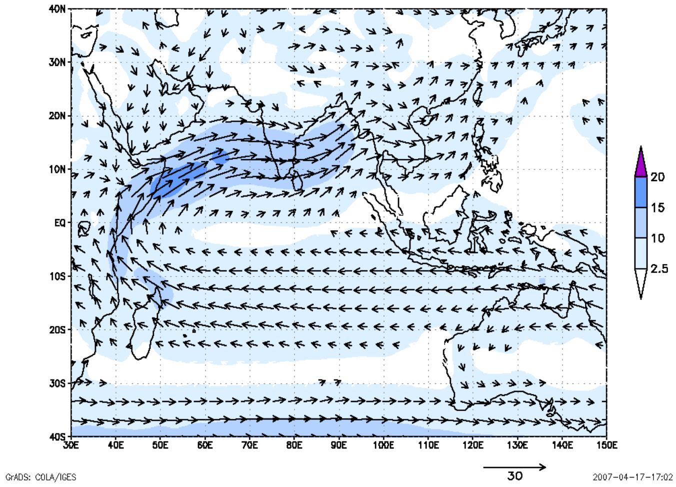

Fig. 1: Composite of 850 hPa wind for Active monsoon days for the climatology

From the detailed analysis of the one month simulations we find that the model climatologies of all India rainfall and average wind variations are close to the observed values. The mean global spatial pattern of wind and rainfall also compare reasonably well [1, 2].

When the monsoon is active, the south westerly wind and rainfall will be strong over the Indian peninsula. The cross equatorial flow covers the whole peninsular region. The figure 1 shows the composite of simulated 850 hpa wind for monsoon time. It compares well with the obseved pattern of wind when the monsoon is active.

From the analysis of the one month simulations we find that the model climatologies of all India rainfall and average wind variations are close to the observed values.The climatological average wind and rainfall compares reasonably well. [3]

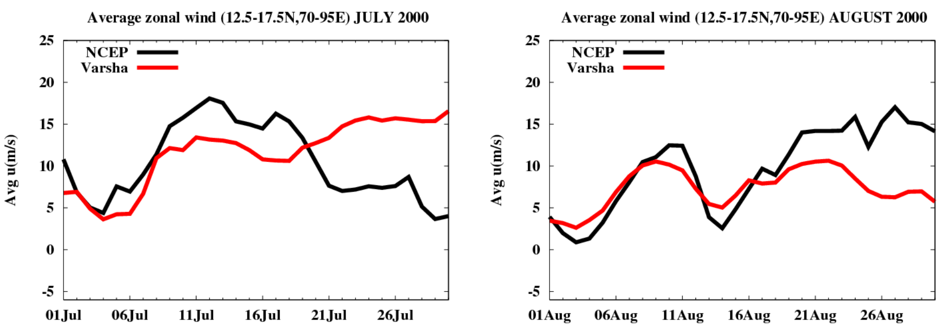

Fig. 2: Observed and simulated variation of 850 hpa wind : 2000

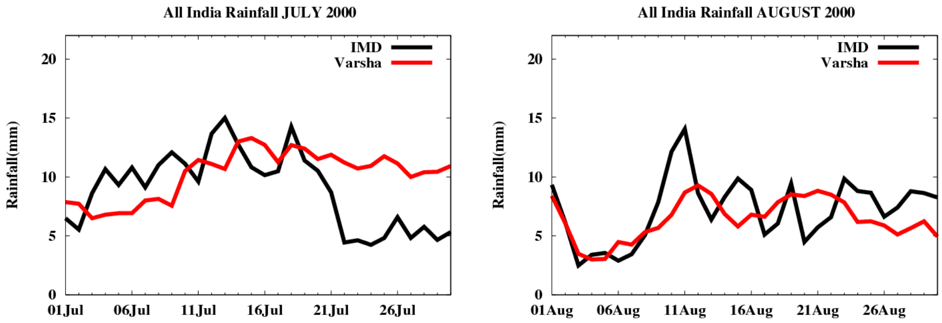

Fig. 3: Observed and simulated variation of All India rainfall: 2000

Correlation coefficients between the observed and simulated wind climatologies are 0.826387, 0.617288, 0.670692 and 0.817792 for June, July, August and September respectively. The overall variation is simulated well, except for July where the bias grows.

In terms of daily variation of particular years, the lower tropospheric zonal wind (LLJ) correlates well with observations for around fifteen days for June, July and August. The simulations of September are comparable well with observations up to 10 days. In some cases (for example the year 2000) the simulated values agree with observations up to the end of the month (see figures 2 and 3)

The daily rainfall forecasts and zonal wind in the peninsular box prepared for each month from June to September of the 21 years are analyzed to quantitatively assess their accuracies. The correlation is calculated for each of the 6 pentads, 1-5, 6-10, 11-15,16-20, 21-25 ,26-30. These are given in the table 1.

The correlation values show that for rainfall, for the month of June, the correlation is good up to first 15 days.In July, the correlation is good up to first 10 days. In August and September the correlation is good only up to first 5 days.

The wind simulation by Varsha shows a high degree of correlation with the observations. Simulations are seen to be highly correlated with the observations for the first 10 days for all the four months. There after June, July and August gives good correlation till 15 days. But correlation of September is seen to be bad after 10 days.

The moving pentad correlations for wind, remains significant up to around twenty days for August, fifteen days for June, July and around eight days for September. For rainfall, the correlation is good for first fifteen days in June, up to ten days in July and around eight days in August and September.

Table 1: Pentad correlations between observations and Varsha simulations of 850 hPa wind and all India rainfall

	WIND				RAINFALL			
DAYS	**JUN**	**JUL**	**AUG**	**SEP**	**JUN**	**JUL**	**AUG**	**SEP**
1-5	0.854	0.755	0.883	0.842	0.840	0.823	0.781	0.787
6-10	0.768	0.704	0.700	0.299	0.762	0.516	0.130	0.330
11-15	0.500	0.480	0.419	-0.118	0.525	0.187	-0.400	-0.008
16-20	0.321	0.376	0.368	-0.342	-0.329	-0.221	0.050	-0.227
21-25	0.095	-0.108	0.331	0.049	-0.084	0.211	0.329	-0.489
26-30	-0.225	-0.225	-0.121	-0.091	0.483	0.096	-0.138	-0.450

4 CONCLUSIONS

One month simulations have been made during the monsoon months, for the years 1986- 2006, with the Varsha GCM version 1.2. This required a large amount of computing power and was carried out in the Flosolver lab. The simulation of large scale quantities such as all India rainfall and box average of low-level wind have been analyzed. From the 21 years of simulation, statistical quantities such as climatological averages, standard deviation and correlations have been calculated. The results are very encouraging. The all India rainfall and 850 hPa wind compare reasonably well with observations. Even with the limitations of the present simulations (climatological SSTs have been used), reasonably good simulations have been made. With further improvements in the model and possibly with the use of predicted SST, we expect that more accurate one month predictions will be made.

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